

Potential quiet areas in Europe inside urban areas

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ABSTRACT

The Environmental Noise Directive (END) recognises the need to preserve areas of good acoustic quality, referred as “quiet areas”, in order to protect the European soundscape and, therefore, improve the wellbeing and quality of life of its citizens. However, the data reported as part of the END contains little information on how the countries, regions and cities define and protect quiet areas in their territories and whether there has been a significant improvement in designation and protection of these areas over the past years. The aim of this paper is to present a methodology to assess quiet urban areas in Europe. The methodology is based on the distinction between areas affected by noise pollution ($L_{den} \geq 55$ dB following the END threshold) from areas potentially unaffected ($L_{den} < 55$ dB). This segmentation is followed by the definition of a typology of urban fabric, which tries to capture different physical components and perception values resulting in different levels of quietness. A test case is presented for Prague, aiming to extend the analysis to European cities reporting data under the END.

Keywords: Noise, Quiet areas, Urban areas

I-INCE Classification of Subject Number: 60, 68

<http://i-ince.org/files/data/classification.pdf>

1. INTRODUCTION

Noise pollution is a growing environmental concern, caused by a varied number of sources and widely present not only in the busiest urban environments but also in natural environments [6]. Transport and industry are the main sources of concern and prolonged exposure can damage human health and adversely affect ecosystems. European legislation aims to reduce noise pollution and highlights the need to preserve currently unaffected areas.

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In this context, article 3 of the END defines “quiet area in an agglomeration” as an area, delimited by the competent authority, for instance which is not exposed to a value of L_{den} or of another appropriate noise indicator greater than a certain value set by the Member State, from any noise source. The definition provided by the END is not explicit on the properties and characteristics of a quiet area since this is left to the criteria of the competent authority according to the principle of subsidiarity. However, it is clear that quiet areas are not areas of complete silence, but the ones that are undisturbed by unwanted or harmful outdoor sound created by human activities [5].

It is widely recognised that quiet areas in the urban context may include parks, areas within building blocks, courtyards, unused land or green areas [4, 5]. The idea of quietness currently encompasses many factors including sound pressure levels, human perception, visual interactions, recreational value, the balance between wanted and unwanted sound, the appropriateness of sound to a given area, and human expectation.

Considering the little information on how the countries, regions and cities define and protect quiet areas and the different approaches addressing quiet areas across Europe [5], the current paper aims to present a methodology to assess potential quiet urban areas in Europe. Having a common approach would facilitate a general understanding on the potential for quiet areas in European cities.

2. FRAMEWORK OF THE ANALYSIS AND PROPOSED METHOD

2.1 Conceptual framework to define potential quiet urban areas

There is not one common definition of quiet areas, and very often the outcome is based more on the experience and planning regulations than a well defined set of criteria.

The designation of “quiet” may accidentally lead to the assumption that a quiet area is an area with a very low noise level when in urban situations, noise levels below 45 dB L_{day} or 40 dB L_{night} are hardly ever found. This is confirmed by the existing literature and practices in Europe concluding that a quiet urban area cannot be defined only based on the noise level [5]. Aspects such as perception by citizens, accessibility, qualities of the areas such as natural, cultural and recreational characteristics, and also the land cover composition of the area (e.g. green area versus built-up area) should be taken into consideration to define a quiet area inside an urban area.

It is also important that citizens’ health should be taken into consideration when planning quiet places in urban environments, in order to provide spaces that can offer opportunities for rest and relaxation and relief from environmental noise and stress mainly produced by road traffic noise [2, 3, 7, 10]. In [3], it is shown that the exposure to natural sounds may have positive health effects by reducing stress, so it is important to modify the focus of the analysis and highlight the potential positive qualities of the sound environment.

Provided then, that cities constitute a mix of uses, activities and interests, quiet urban areas should follow the same pattern and become elements integrated in the urban structure and not isolated spots. It is important not to limit solely to green urban areas, as the existence of quiet neighbourhoods or commercial districts, that could develop the restorative function mentioned above, should also be taken into consideration.

Therefore, in our approach, we do not limit to green urban areas, although they tend to be the primary objective given the multiple benefits that they provide. The availability of greenery (nearby trees, opportunities for gardening and places for talking walks) in the different spaces of the city also plays an important role and are highly valued components of urban nature that increases satisfaction and well-being in urban residents, although maybe located in the noisy areas of the city [1, 7]. Furthermore, different types

of urban spaces like court yards, pedestrian street, square, small park or resting area with little traffic contribute to the quiet areas as a network.

In that sense there is a very interesting proposal done in [11] and based in Berlin city, that defines an “everyday quiet area” in the following terms: “a small, public, quiet spot embedded in the city fabric, at a walking distance from the places we work and live, where social interaction and spoken communication are not disturbed”. According to this definition, a set of criteria for identifying those “everyday quiet areas” in cities have been established: people’s preferences, accessibility, small size (< 1Ha), neighbourhood scale (< 30 Ha, in the case of Berlin), the distance and human voices that can be heard in the space.

2.2 Criteria to define potential quiet urban areas

Against the background explained in the previous section it is possible to identify a set of characteristics that could define (to different degree) potential quiet (urban) areas, summarized in Table 1.

Table 1. Set of criteria to define potential quiet urban areas

CRITERIA	Definition	Observations
Noise limit values	Areas covered and uncovered by the noise contour map of different sources. The focus will be on areas with noise levels below 55 dB L _{den} .	<ul style="list-style-type: none"> - The noise level limit should be for man-made sounds and not natural sounds such as running or falling water or bird song. Lower noise limits are required as the degree of natural features falls. - Apparently, higher noise levels than 55 dB L_{den} (e.g. 60 dB L_{den}) do not exclude an experience of quietness if the surrounding sound pressure level is 10-20 dB (A) higher. - Different limits are specified in national legislations concerning not solely quiet areas but also other types of urban areas (recreational, schools, hospitals, etc.)
Open spaces	Areas outside buildings	
Aesthetic values of quiet areas	Attributes related to people’s perception of quietness and percentage of natural features present within a scene	<ul style="list-style-type: none"> - Perception indicators such as pleasant nature, nice colors and odors, clean,... - Presence of natural features such as trees, gardening,... - Availability of this information at European level
Accessibility and walking distance	Accessibility to the area	
Minimum area (size)	Size of the area	<ul style="list-style-type: none"> - Not necessarily exclusive criteria. Based on the proposal from Berlin study, very small calm places were also identified as “everyday quiet areas”
Ownership	Public or private area	<ul style="list-style-type: none"> - It could be relevant to know the ownership in terms of capability to be a quiet area for a reduced number of people or a public space freely accessible

Beyond these elements, there are aspects that are getting more and more attention:

- **Soundscape.** The use of specific sounds (human voices, natural sounds) in an open space could improve the perception and comfort of the receptor about the quality of the area.
- **Innovative approaches with strong involvement of citizens.** For example, the Hush City project [8] used a novel mixed framework – the “open source soundscapes” methodology – envisioned to actively involve people in identifying, assessing and planning “everyday quiet areas” in cities, by combining the soundscape approach, the citizen science paradigm and the use of a new mobile.

Provided all the criteria proposed, it is clear that there is not a unique typology of quiet areas, and even for example, pedestrian streets [4, 9] may have a certain role and

value in potential quiet areas or neighbourhoods. So this criteria would help to analyse minimum homogeneous units defined by different elements within the city that could constitute potential quiet areas (e.g. street with trees, backyard, inner yard, green urban area, buildings' area,...), which will be grouped in main categories that would be relevant for management and to potentially establish a criteria to classify the different cities analysed.

Translating all these elements to the European context is not feasible since some aspects require information or intervention (such as questionnaires to citizens) at a scale out of the scope of this paper. Therefore, we take the elements and principles that could be developed at European scale which will provide a framework that could be further developed with local information and participation.

The main characteristics that are then considered, are described as follows:

- Quiet areas have a certain acoustic quality: the data that we will use in the analysis will be the noise contour maps provided by the END and we will consider quiet areas the surface of the urban areas below 55 dB L_{den} and noisy areas the surface of the urban areas above 55 dB L_{den} .
- Quiet areas are not limited to green areas, neither isolated spots. However, green areas are very relevant given the multiple benefits that they provide, and also in accordance with the green infrastructure and ecosystem services paradigm.
- The urban fabric is also a component of the quiet and relevant to establish connections with green areas and open spaces.

The minimum homogeneous units that will be taken into consideration may define the urban structure of (potential) quiet areas. Each building block may be part of a wider network or, on the opposite, isolated structures. Moreover, even if there exist a continuity of the same unit, it would be possible to define functionalities. For example, a network of streets could be considered connectors, with certain sound quality, that leads to wider spaces (with additional qualities/functionalities) like parks.

The combination of this minimum homogeneous units could bring to another analytical level of the urban structure (e.g. neighbourhood). This is important to allow the provision of a full picture of the city (fragmentation, quality, accessibility), and not only a single indicator like percentage or number of quiet areas at city level. Moreover, the characterization at neighbourhood or at sub-district level may a lot the possibility to allocate relevant public services such as hospitals, libraries, schools, etc. and determine in which noise context are placed.

2.3. Data used and proposed method

2.3.1. Data used

The data necessary to implement this analysis must have two premises, a temporal scale comparable with noise contour maps reporting periods (2012 and 2017), and a European coverage in order to extend this methodology to other urban areas. Under these conditions, the best data currently available is Corine land cover data. It consists of an inventory of land cover in 44 classes for the years 1990, 2000, 2006, 2012 and 2018.

Another option considered was the Urban Atlas datasets that provides pan-European comparable land use and land cover data for Functional Urban Areas (FUA) detailed land cover and land use information over major EU city areas. Currently is available for the years 2006 and 2012. The publication of Urban Atlas data for 2018 is expected by the end of 2019.

Table 2. Resolution of CLC and Urban Atlas 2012

CORINE Land Cover (CLC) 2012-2018	Urban Atlas 2012
- Minimum Mapping Unit (MMU) of 25 hectares (ha) for areal phenomena and a minimum width of 100 m for linear phenomena.	- 17 urban classes with MMU 0.25 ha
- 44 classes of land cover	- 10 rural classes with MMU 1ha

The spatial resolution of Urban Atlas 2012, especially with regard to urban classes, makes this dataset the best option for analysing urban phenomena. However, the implementation of the methodological proposal with CORINE Land Cover due to its time series coinciding with noise reporting periods is a valid approach to analyse potential quiet urban areas. We propose also an analysis using Urban Atlas 2012 and noise contour maps 2012 in order to evaluate the results but without assessing the changes.

The data available at European level for the analysis is described in Table 3:

Table 3. Datasets used for the analysis of potential quiet urban areas at EU level

Criteria	Dataset	
Noise level	Noise contour maps (L_{den}) for 2012 and 2017 reference years'	
Land cover	Urban Atlas 2012	CORINE Land Cover 2012 CORINE Land Cover 2018

2.3.2. Methodological approach

The methodology for identifying potential quiet urban areas is described in Figure 1. One analysis has been done with Corine land cover using CLC 2012 and CLC 2018 with noise contour maps 2012 and noise contour maps 2017. In addition, analysis of changes for these two reporting periods and land cover has been performed. To test the methodology with a more accurate land cover, we applied the same process using Urban Atlas 2012 with noise contour maps 2012.

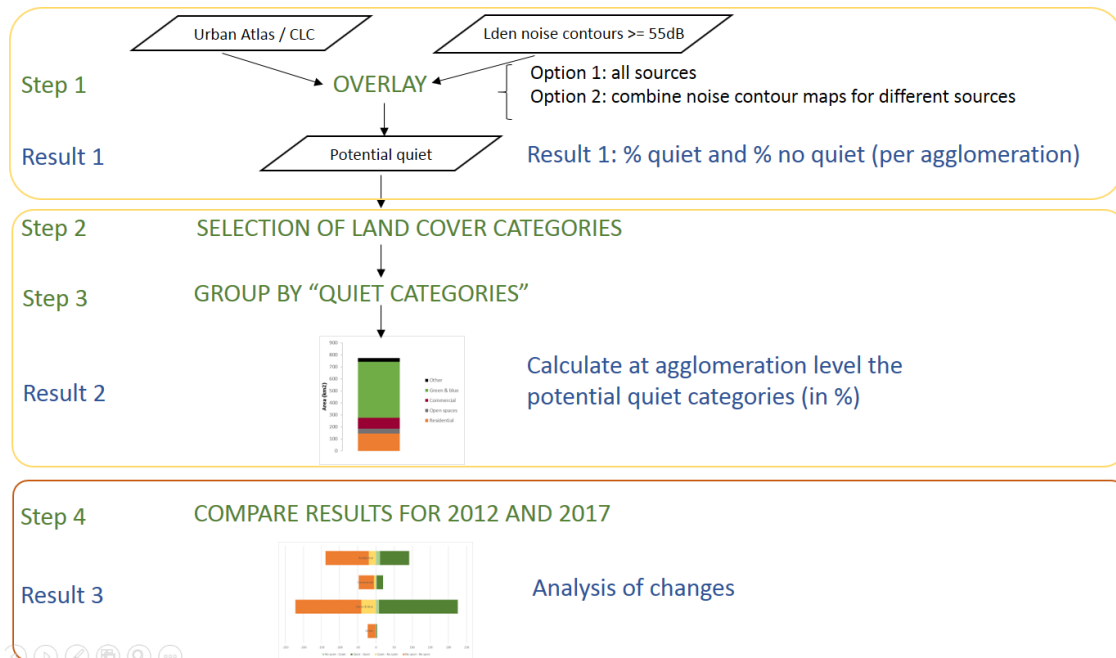


Figure 1. Data Flow diagram of the proposed analysis

Step 1: Overlay analysis of noise contour maps (n.c.m) $\geq 55\text{dB } L_{den}$ with Land Cover. This overlay operation combine the attributes of all the datasets involved and it allows us to identify all the land cover uses inside and outside the areas greater than or equal to 55dB. For noise contour maps we have two types of layers one single layer for

all noise sources (agglomeration all) or a combination of noise contour maps layers for the different sources (agglomeration road, rail, air, industry) greater than or equal to 55dB. The Land cover used was previously clipped with the agglomeration delineation.

Result 1: Potential quiet and noisy land cover areas inside agglomeration. For CLC 2012 and 2018 results for n.c.m 2012 and 2017 (for Urban Atlas 2012, only n.c.m 2012)

Step 2: Reclassification of land cover uses into categories. Proposal of Reclassification of land cover categories for CLC and Urban Atlas (see Table 4).

Step 3: Group by categories

Result 2: Statistical analysis of the potential quiet categories inside agglomeration (in %). For CLC results for n.c.m 2012 and 2017 (for Urban Atlas 2012 only n.c.m 2012).

Step 4: For CLC Comparison of the results for years 2012 and 2017.

Results 3: Analysis of changes 2012-2017.

2.3.3. Proposed reclassification of land cover classes

Table 4. Proposed classes for the analysis (from Urban Atlas classes and CLC classes)

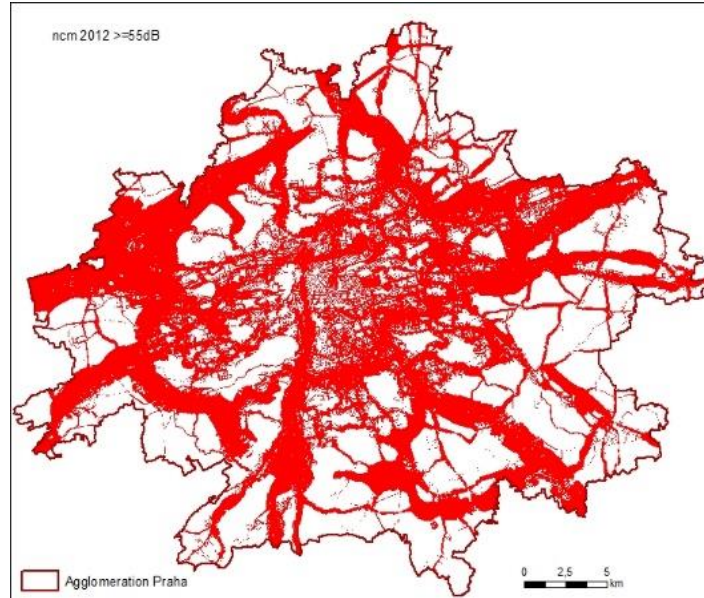
Proposed classes	Urban Atlas classes	CORINE Land Cover classes
Residential	Built-up areas and their associated land, such as gardens, parks, planted areas and non-surfaced public areas. Basically the classes 111 and 112 are distinguished by their degree of soil sealing	Areas mainly occupied by dwellings and buildings used by administrative /public utilities, including their connected areas (associated lands, approach road network, parking lots).
Commercial – recreational	Industrial, commercial, public, military or private units. All sports and leisure facilities including associated land, whether public or commercially managed.	Industrial or commercial units and public facilities. Includes also areas used for sports, leisure and recreation purposes. Camping grounds, sports grounds, leisure parks, golf courses, racecourses etc. belong to this class, as well as formal parks not surrounded by urban areas
Open spaces (streets and roads)	Other roads and associated land streets, crossings, intersections and parking areas, including roundabouts. Also includes land without current use. Areas in the vicinity of artificial surfaces still waiting to be used or re-used.	(*)
Green & blue	Public green areas for predominantly recreational use such as gardens, zoos, parks, castle parks and cemeteries. Arable land, Orchards, forests, water.	Green urban areas. This class is assigned for urban greenery, which usually has recreational or ornamental character and is usually accessible for the public. Includes also CLC classes from 211 to 523 and contains forests and water courses.
Other	Contains classes not included in other categories	Contains classes not included in other categories.

(*) In CLC classes, we cannot identify the category **Open spaces (streets and roads)** as we did for Urban Atlas because streets and roads are mainly included in the continuous and discontinuous urban fabric (111-112).

3. RESULTS AND DISCUSSION

3.1. Potential quiet urban areas in Prague (reference year 2017)

About 50% of the city of Prague (386 km²) is below 55 dB L_{den} and, therefore, integrates the potential quiet urban areas. The distribution of these areas is fragmented by a radial road network crossed by circular rings (see Map 1).



Map 1. Distribution of noisy (in red) and quiet areas (white areas), based on the noise contour map covering all noise sources above 55 dB L_{den} (source: Reportnet).

Within this large area below 55 dB L_{den}, one could distinguish different typologies of quiet according to the urban fabric (see Figure 2):

- Green and blue areas contribute to more than half of the potential quiet urban areas (68%), which are the ones that would play a major role as quiet since integrate the benefit of the green. Although there is not a homogenous distribution, with a clear radial pattern, important green packs are observed close to the centre as can be seen in Figure 2.
- Residential areas contribute to 18% to the potential quiet urban areas in Prague. Those areas are located close to city centre, the denser part of the urban fabric.
- Commercial and recreational areas cover 9% of the total area of potential quiet urban areas in Prague which, together with the open spaces' category representing 4%, could represent places to enable connections between urban fabric and green & blue areas through potential quiet corridors. This group is expected to be the less quiet but, especially in the case of the open spaces' categories, one could establish the link with the proposal done in [11].

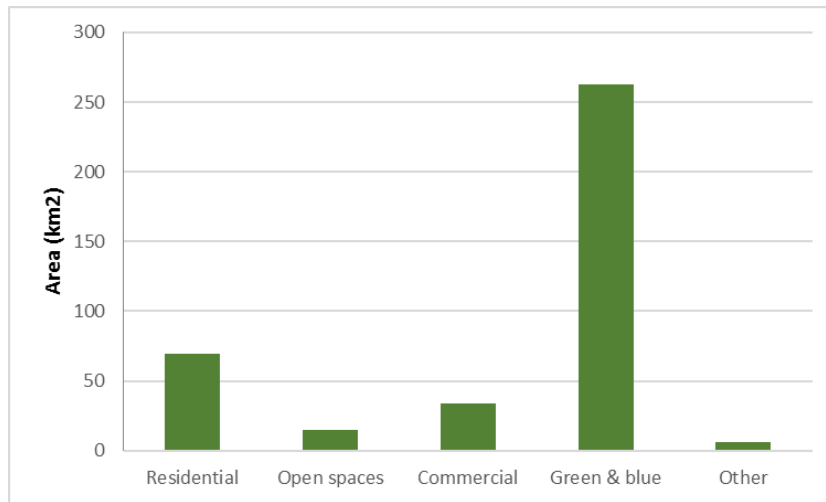


Figure 2. Typologies of quiet urban areas in Prague: distribution of reclassified land cover classes below 55 dB L_{den}

A further analysis has been developed to investigate the dB values (in 5 dB bands) that are encountered in the different categories in the 386 km² of potential quiet urban areas in Prague. The results are displayed in Figure 3. Prague delivered the complete noise map covering all noise sources and providing data below 55 dB L_{den} , so that's why this information has been analysed.

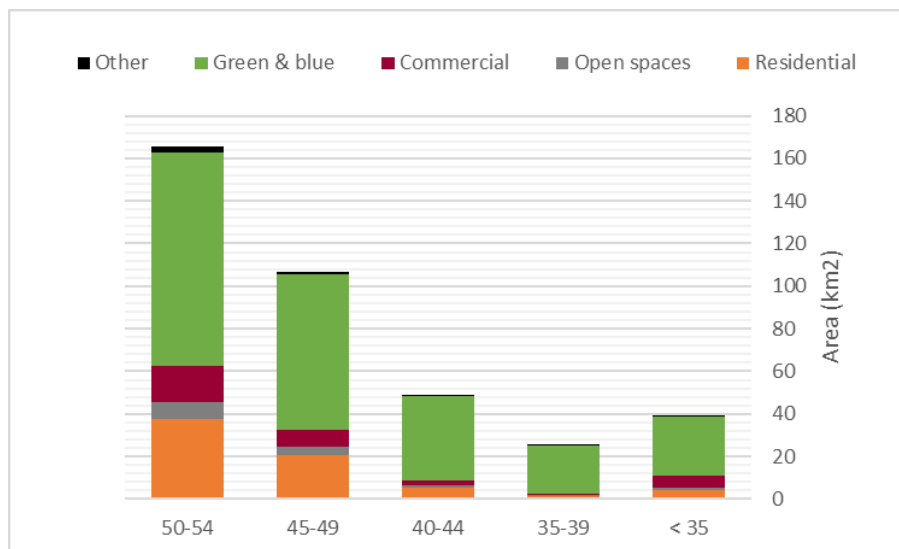


Figure 3. Distribution in 5 dB bands of reclassified land cover classes in Prague below 55 dB L_{den}

As can be seen, the blue and green areas are represented in all noise bands below 55 dB L_{den} , with the majority of km² in the bands 50-54 dB and 45-48 dB, but the highest percentage present in the lower noise bands: 40-44dB, 35-39dB and below 35 dB. This is somehow expected due to the fact that the main noise source at European level is road traffic noise, which is mainly located next to road transport infrastructures and in denser urban fabric areas, and far from what has been categorized as green and blue areas (covering forest areas, agricultural areas, green urban areas and water areas).

Residential, open spaces and commercial and recreational categories are found in bands 50-54 dB and 45-49 dB, covering a total of 95 km² out of a total of 117 km², representing the 81% of how the areas are distributed below 55 dB L_{den} . Those 3

categories compared to the green and blue category can be considered less quiet, so the result obtained follows the expectations of those uses.

Broadening the scope of the analysis to the entire city (Figure 4) one could observe that the distribution of residential areas is similar in the potential quiet and noisy areas. However, the extension of green and blue is higher in the potential quiet part of Prague, compared with the noisy area. It is important to highlight the role of green and blue areas even on the noisy area since they are important for people's health and could, partially, attenuate negative impact of environmental stress.

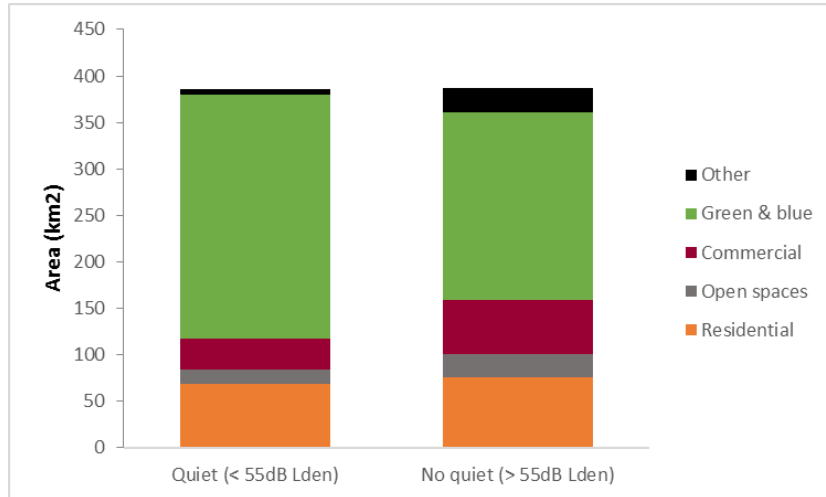
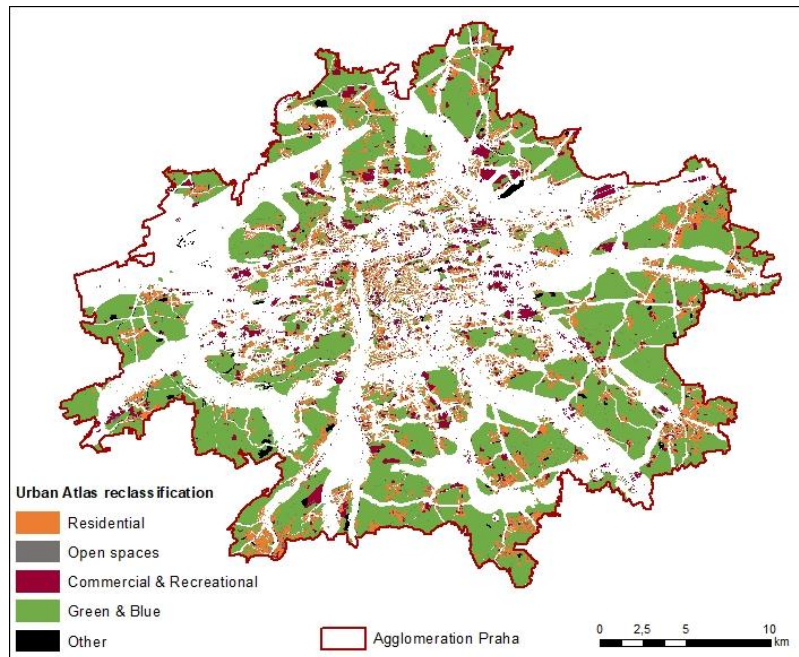


Figure 4. Distribution of reclassified land cover classes in Prague: distinction between potential quiet areas and noisy areas

Map 2 shows that large low noise areas or potential quiet urban areas are located in the outer ring of the city, and many small areas of the 4 categories identified are found in the central part of the city, where the majority of urban fabric is concentrated.

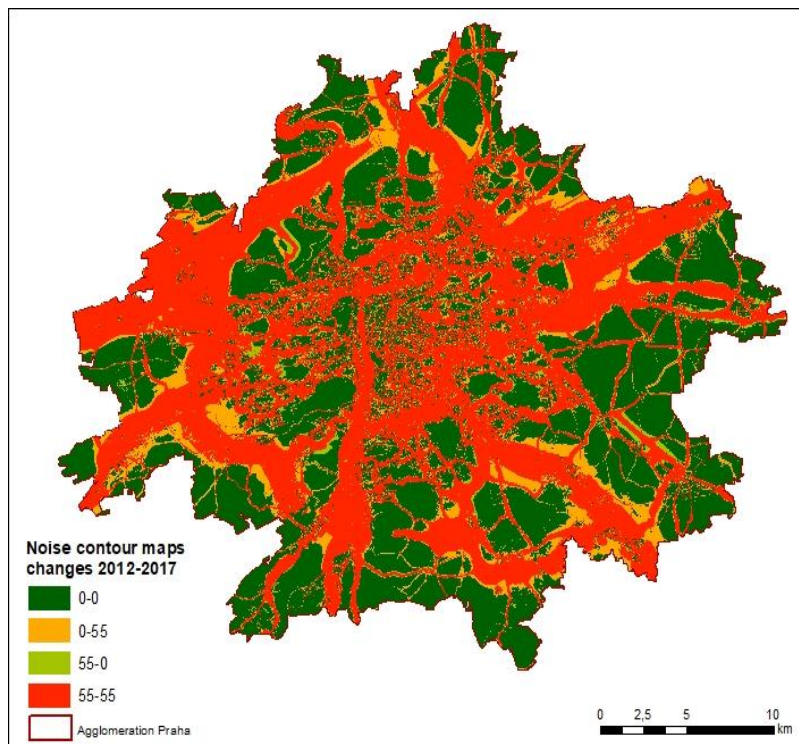
It can be also highlighted that in the central part of the city, and provided that the streets are narrower and therefore, not able to cope with high traffic levels such as in the outer ring, we can observe quite a high concentration of small low noise areas mainly categorized as residential areas. We can expect that these small low noise areas that are encountered in the city centre are formed by buildings that may create a sound shadow creating a potential small quiet area such as courts (public or private), gardens and small streets in and between closed city blocks.

With this kind of city structure (which is encountered in the majority of cities at European level), these results and the ones studied and highlighted in [2, 11], potential small quiet urban areas within walking distance that could be conformed by a street, square, small park or water inside urban fabric in combination with larger areas in the outer part of the city would be a potential solution to enhance the positive effects of accessibility to quiet places and moderating the adverse effects of exposure to noise.



Map 2. Distribution of reclassified land cover classes within potential quiet urban areas in Prague (Urban Atlas, 2012; noise contour map including all noise sources, 2012)

3.2. Changes on potential quiet areas between 2012 and 2017 reference years



Map 3. Changes on potential quiet areas between 2012 and 2017 reference years in Prague

Between 2007 and 2012 there has been a decrease on the overall potential quiet urban area. In general, the increase of noisy area in 2017 is contiguous to existing noisy areas in 2012 in the outer skirts of the city. This is linked to further urban development in these areas (see Map 3). There is an improvement in some parts of the city concerning potential quietness that does not counterbalance the increase of potential noisy areas.

As can be seen in Figure 5, the decrease of quiet urban areas is at expenses of green and blue areas. In particular it affects agricultural areas and open spaces.

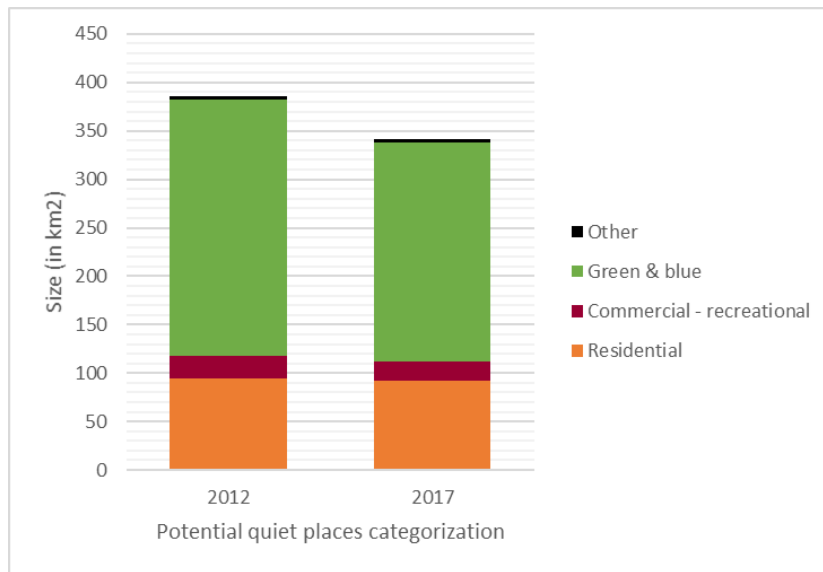


Figure 5. Change of the distribution of reclassified land cover classes in potential quiet urban areas in Prague (2012 versus 2017)

Provided the fact that noisy area increases mainly in green and blue category and in residential category from 2012 to 2017 (see Figure 6), one may suppose that the quality of environmental noise at city level has decreased. This situation affects primarily areas where people live and work (e.g. residential category) and areas in the outer circle of the city area where people can look for relief from environmental stress (e.g. green and blue). As can be observed in Figure 6, improvements in some parts of the city area have occurred in both categories, but the net balance is negative in both cases implying a potential decrease of quality of life for inhabitants in Prague provided the decrease of available potential quiet areas. In this context, it would be important to make special emphasis of potential small quiet urban areas located in urban fabric as “noise-free” sections in a noisy surrounding, and try to protect them and maintain it to reduce long-term noise exposure especially in city centre.

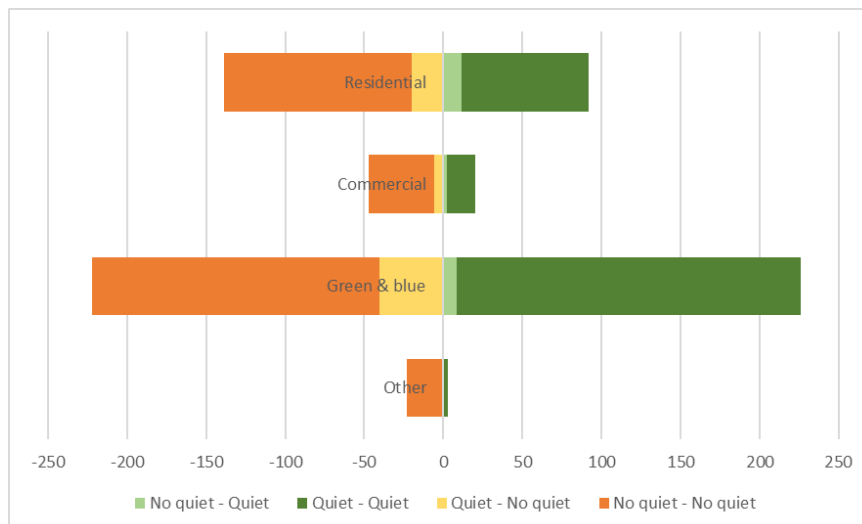


Figure 6. Change between quiet and noisy areas in Prague from 2012 to 2017 differentiating between the reclassified land cover classes

4. CONCLUSIONS

The conceptual framework and methodological approach presented in this article facilitates a systematic and comparable analysis of quiet urban areas in Europe, integrating the complexity of the city structure.

This analysis allows the characterization of potential quiet areas at city level and the dynamics occurring from the environmental noise point of view.

The analysis has been done using available data at European level, but the method could also be applied with data at local level, providing results at a more refined scale. Nevertheless, the European context would allow the characterization and comparison of different cities based not only on the noise exposure factor but also on the distribution and composition of potential quiet / noisy areas at city level.

With the identification of quiet areas at city level (inside the city, in the peri-urban region and in the outer circle of the city) and its potential protection or maintenance, a positive effect on the urban population would be expected, improving quality of life and accessibility to relaxing and positive sound urban environments.

It is also relevant to involve citizens in the definition and protection of quiet areas in cities. There have been a lot of studies asking for their collaboration in assessment of the current situation at their city (e.g. through questionnaires, soundwalks, etc.), but there needs to be a proactive communication and involvement of citizens, considering that they are the primarily beneficiaries or harmed of well-being and quality of life in their respective cities.

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